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03 Body Fluids and Circulation

1. Introduction :

- You have learnt that all living cells have to be provided with nutrients, O_2 and other essential substances. Also, the waste or harmful substances produced, have to be removed continuously for healthy functioning of tissues.
- It is therefore, essential to have efficient mechanisms for the movement of these substances to the cells and from the cells.
- Different groups of animals have evolved different methods for this transport.
- Simple organisms like sponges and coelenterates circulate water from their surroundings through their body cavities to facilitate the cells to exchange these substances.
- More complex organisms use special fluids within their bodies to transport such materials.
- Blood is the most commonly used body fluid by most of the higher organisms including humans for this purpose.
- Another body fluid, lymph, also helps in the transport of certain substances.
- Lymph helps in the transport of certain substances like fat.
- In this chapter, you will learn about the composition and properties of blood and lymph (tissue fluid) and the mechanism of circulation of blood.
- The study of blood vascular system is called Angiology.
- Father of Angiology is William Harvey.
- The study of heart is called Cardiology

2. Blood :

- Fluid connective tissue / special connective tissue
- Mesodermal in origin
- Blood is a false connective tissue because -
  (a) Cells of blood have no power of division.
  (b) Matrix is devoid of fibres.
  (c) Matrix of blood is not secreted by blood cells.
- Study of Blood — **Haematology**
- Process of blood formation **Haemopoiesis** (in bone marrow).

Colour	—	Red
pH	—	7.4 (Slightly alkaline)
Weight	—	7 to 8% of body weight
Volume	—	5 - 6 litres in male and 4 - 5 litres in female.

- Anticoagulant present in human blood – Heparin

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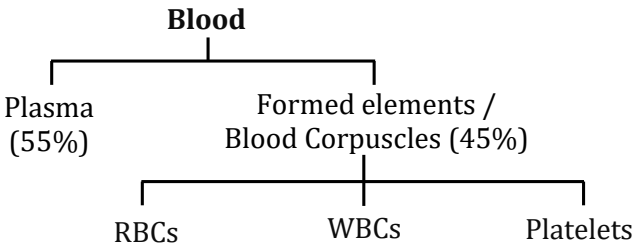
(A) Composition of Blood :

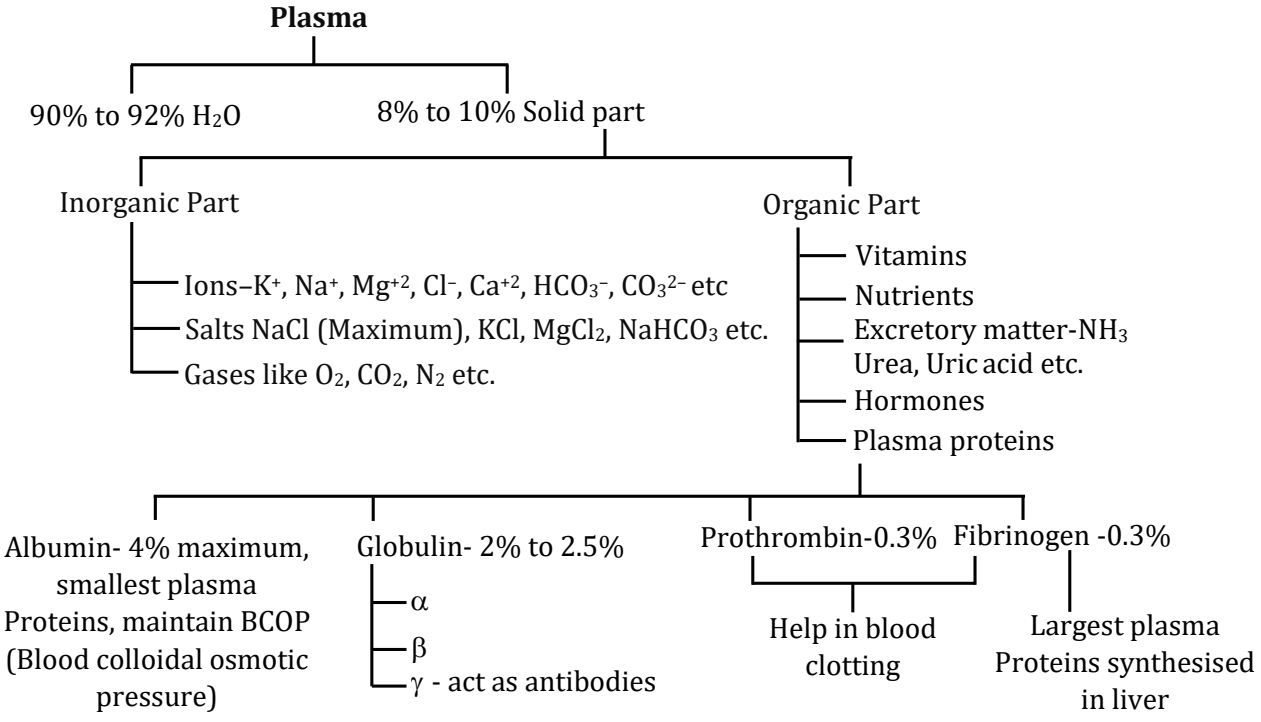
1. Liquid Part — Matrix — Plasma 55%
2. Solid Part — Blood corpuscles — 45% **(RBC, WBC & Platelets)**



Plasms is a straw colored viscous fluid constituting 55% if the blood

(B) Plasma :

- When separated from the rest of the blood, plasma is light yellow liquid.



Ratio of albumin and globulin = 2 : 1

(C) RBC (Erythrocytes) : Red blood cells (RBC) or erythrocytes are the most abundant of all the cells in blood.

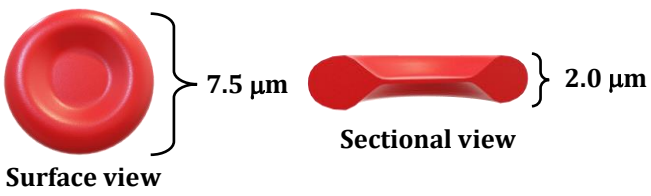
Number :

- Number of RBC in healthy adult male - **5 million** to **5.5 million** of RBCs mm^3 of blood.
- Number of RBC in healthy adult female - **4.5 million** to **5 million** of RBCs mm^3 of blood.
- Number of RBC in healthy new born baby - **6.8 million** of RBCs mm^3 of blood.
- Condition of increased RBC count is called **Polycythemia**. This condition occurs at hill station (High altitudes).
- Condition of decreased RBC count is called **Anaemia**.

Shape and Size :

- In most of the mammals, mature RBCs are **biconcave**, disc like, circular in cross section. (**Biconcave shape of RBC increases surface area**)
  Exception :- Camel & Lama are mammals with biconvex & oval shaped RBCs.

In Humans-7.5μm (Diameter)



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RBCs in Different Conditions of Solutions :

- Change in the shape of RBC is called as **Poikilocytosis**.
- If RBC is kept in hypertonic solution it will shrink (crenation).
- In hypotonic solution it will burst.
- 0.8 - 1% NaCl solution is isotonic for RBC. (0.9% of NaCl)
- Glucose 5.0% (w/v) solution is isotonic for RBC.

Structural Details of RBC :

- Mature mammalian RBCs are devoid of nucleus **(Enucleated).**
- Plasma membrane of RBC is called **Donnan's membrane**.
- ER (Endoplasmic reticulum), GC (Golgi complex), Ribosomes & Mitochondria are absent in mature mammalian RBC.
- Network of structural protein called stomatin is present which forms a spongy cytoskeleton.
- **Carbonic anhydrase (One of the fastest enzyme) -** Zinc containing enzyme which helps in transportation of CO_2.

Haemoglobin (Hb) :

- RBCs have a **red coloured**, **iron containing** complex **protein** called **haemoglobin**, hence the colour and name of these cells.
- **Red coloured respiratory pigment which helps in transportation of O_2 & CO_2. (function)**
- A healthy individual has **12-16 gms** of haemoglobin in every 100 ml of blood.

Haemoglobin(Hb)

2 components

Haem - 5% (Iron and Porphyrin)

Iron present in the form of Fe^{+2} (ferrous ions)

HbA $\rightarrow$ $2\alpha + 2\beta$
HbF $\rightarrow$ $2\alpha + 2\gamma$

HbA - Adult haemoglobin
HbF - Foetal haemoglobin

Globin- 95% (Protein part)

Each molecule of globin protein is composed of 4 polypeptide chains :-

- 2α polypeptide chain having 141 amino acids. (compulsory)
- 2β, 2γ or 2δ polypeptide chains having 146 amino acids.

Formation of RBC (Erythropoiesis) :

- Organs which produce RBCs are called Erythropoietic organs.
- Hormone which stimulate Erythropoiesis is called **Erythropoietin**, synthesized by Kidney.
- **1st RBC** is produced by **yolk sac**.
- **During embryonic life** RBC are produced by **Liver, Spleen, Placenta, Thymus gland**.
- In **adult stage** RBCs are produced by **RBM (Red Bone marrow)**.

Life Span of RBC :

- Human adult — **120 days**
- New Born Baby — **100 days**
- 1% RBC are destroy daily but in same number new RBC enter into the blood.
- **Destruction** of RBC occurs in **spleen**. (**Graveyard of RBC**)
- **Spleen** also stores **extra blood** corpuscles so it is also called **Blood Bank of Body**.

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BEGINNER'S BOX-1 PLASMA AND RBC

1. Which of the following is most abundant in blood?
(1) RBC (2) WBC (3) Platelets (4) All are equal

2. Mammalian mature RBC does not contain :-
(1) Membrane bounded cell organelles
(2) Carbonic anhydrase
(3) Haemoglobin
(4) Enzyme of glycolyte pathway

3. Organisms which circulate water from their surrounding through their body cavities to facilitate the cells to exchange the substances are
(1) Porifera (2) Sponges (3) Both (1) and (2) (4) Insects

4. Father of Angiology is :-
(1) Hippocrates (2) William Harvey (3) Aristotle (4) Linnaeus

5. Human blood consists of
(1) Fluid matrix (2) Plasma (3) Formed elements (4) All the above

6. Match the following columns.

Column-I		Column-II	
A	Fibrinogen	1	Clotting or coagulation of blood
B	Globulin	2	Defence mechanism of Body
C	Albumin	3	Osmotic balance

(1) A—3, B—2, C—1
(2) A—3, B—1, C—2
(3) A—2, B—1, C—3
(4) A—1, B—2, C—3

7. Formed elements present in the human blood are :-
I. Erythrocytes II. Leucocytes III. Platelets IV. Plasma V. Lymph
Choose the correct option.
(1) I, II and III (2) II, III and IV
(3) III, IV and V (4) I, II, III, IV and V

8. Formed element constitutes what percentage of the blood?
(1) 55% of blood (2) 45% of blood
(3) 35% of blood (4) 25% of blood

9. In humans, RBCs are formed in :-
(1) Red bone marrow (2) Heart (3) Lungs (4) Yellow bone marrow

10. Properties of human RBCs are :-
I. Devoid of nucleus II. Formed in bone marrow
III. Possess healing properties IV. Biconcave in shape
V. Help in blood clotting.
Choose the option with correct properties.
(1) I, II and III (2) I, II and IV (3) III, IV and V (4) III, II and IV

11. Sponges and coelenterates circulate which fluid in their body cavities :-
(1) Blood (2) Lymph (3) Tissue fluid (4) Water

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12. Which of the following is a false connective tissue?
(1) Tendon (2) Ligament (3) Cartilage (4) Blood

13. Anticoagulant found in human blood is :-
(1) Hirudin (2) Heparin (3) Lysozyme (4) Creatinine

14. Which of the following is the correct function of albumin protein?
(1) Maintain BCOP (Blood Colloidal Osmotic Pressure)
(2) Primarily involved in defense mechanism of the body
(3) Help in blood clotting
(4) Help in formation of heparin

15. Find the correct statement about fibrinogens :-
(1) Largest plasma proteins (2) Help in blood clotting
(3) Synthesized in liver (4) All of the above

16. Plasma proteins which help in blood clotting are :-
(1) Globulins (2) Prothrombins
(3) Fibrinogens (4) Both (2) & (3)

17. RBC count in an adult human male is :-
(1) 5 to 5.5 million/mm^3 (2) 3.5 to 4.5 million/mm^3
(3) 3. 5 to 5.5 million/mm^3 (4) 6.8 million/mm^3

18. Mature RBC of human lacks :-
(1) Nucleus (2) Mitochondria (3) Ribosomes (4) All of these

19. Foetal haemoglobin has :-
(1) $2\alpha + 2\beta$ Polypeptide chains
(2) $2\alpha + 2\gamma$ Polypeptide chains
(3) $2\alpha + 2\delta$ Polypeptide chains
(4) $2\beta + 2\gamma$ Polypeptide chains

20. Hormone erythropoietin is synthesized by :-
(1) Liver (2) Heart (3) Red bone marrow (4) Kidney

21. Graveyard of RBC is :-
(1) Brain (2) Spleen (3) Kidney (4) Large intestine

(D) WBCs (White Blood Cells) :

- **Also called Leucocytes**
- **Lack haemoglobin (Colourless)**
- **Total leucocyte count (TLC) :** 6000 – 8000 / mm^3 of blood
- **Differential leucocyte count (DLC):** (%) of different type of leucocyte in blood.
  Acidophils — 2 – 3% of TLC
  Basophils — 0.5% – 1% of TLC (minimum)
  Neutrophils — 60 – 65% of TLC (maximum)
  Monocytes — 6 – 8% of TLC
  Lymphocytes — 20 – 25% of TLC
- **Leucocytosis :-** Increase in TLC
- **Leucocytopenia :-** Decrease in TLC
- **Leukemia:-** Abnormal increase in TLC (more than 1 Lakh), it is also called blood cancer.

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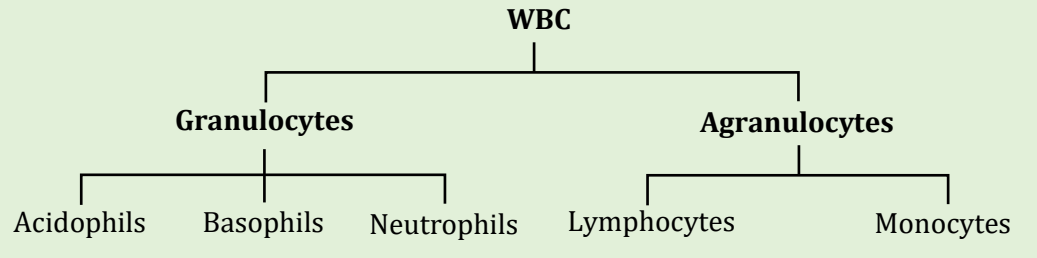
Types of WBCs :

(i) Granulocytes (Granules Present in Cytoplasm which can be stained by specific dyes)
(ii) Agranulocytes (Granules Absent in Cytoplasm so cannot be stained by specific dyes)



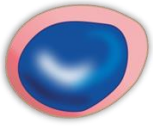
Granulocytes :

- Due to presence of lobed nucleus they are also called polymorphonuclear WBC.
- Are of three types :-
  (1) Acidophils/Eosinophils **(2) Basophils** **(3) Neutrophils**

Granulocytes			
	Acidophiles / Eosinophils	**Basophils**	**Neutrophils**
Staining	Acidic dye like Eosin	Basic dye like methylene blue	Combination of basic and acid dyes
Nucleus	Bilobed	S-shape, 2 to 3 lobes	3 to 5 lobes
Functions	Protect body against allergy & endo parasitic infection	Secretion & transportation of heparin, histamine & serotonin	Micro police man of blood Destroy bacteria & viruses by phagocytosis
Microscopic view			

Agranulocytes :

- Due to absence of lobed nucleus they are also called mononuclear WBC.
- Cytoplasm is clear.
- Are of two types :- **(i) Monocytes** **(ii) Lymphocytes**

Agranulocytes		
	Monocytes	**Lymphocytes**
Nucleus	Kidney shaped/bean shaped	Large and spherical
Functions	Phagocytic in nature (macropoliceman & scavenger cell)	T–Lymphocytes B–Lymphocytes
Microscopic view		

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Types of Lymphocytes :-

(i) T–Lymphocytes :-

- They are produced in bone marrow but get matured in thymus gland.
- Stimulate B–lymphocytes to produce antibody.

(ii) B–Lymphocytes :-

- They are produced and matured in bone marrow.
- There function is to produce & transport antibodies.

(E) Platelets (Thrombocytes) :

- Shape is disc like, oval shaped or biconvex.
- Size is about **2 - 3 μm**.
- Life span is about : **2 – 5 days.**
- Normal platelets count : **1.5 – 3.5 lakh/mm^3** of blood.
- Decrease in number of blood platelets is called Thrombocytopenia, cause clotting disorders which leads to excessive loss of blood from the body.
- Non-nucleated.
- **Platelets are only found in mammals.**
- Critical count of Thrombocytes is 40,000/mm^3. If number is less than critical count then red spots or rashes appears on the skin called **Purpura disease**.
- In their cytoplasm basophilic granules are present which can be stained by **methylene blue**.

Formation:

- These are **cell fragments** derived from **megakaryocyte** cells of bone marrow. (Special Cells)

Functions:

- **Coagulation** or **blood clotting**
- Repair endothelium of blood vascular system by the formation of **platelet plug**.
- Synthesize **thromboplastin** which help in to blood clotting.
- Synthesize **serotonin**.

BEGINNER'S BOX-2 — PLASMA AND RBC

1. In DLC neutrophil found as :-
(1) 0 - 2% (2) 2 - 8% (3) 25% (4) 65%

2. Critical count of Platelets is :-
(1) 40,000/mm^3 (2) 1 lac /mm^3 (3) 2 lac /mm^3 (4) 4 lac /mm^3

3. Macro policeman of blood is :-
(1) Acidophils (2) Monocytes (3) Neutrophils (4) Basophils

4. Leucocytes are colourless due to :-
(1) Lack of water
(2) Lack of haemoglobin
(3) Presence of extra water
(4) Presence of haemoglobin

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5. Leucocytes are characterised by :-

I. They are nucleated. II. They are enucleated like RBC.

III. They are 6000-8000 mm^{-3} of blood. IV. They are long lived.

V. They are short lived.

Choose the appropriate option with correct properties.

(1) I, III and V (2) II, IV and V (3) I, IV and V (4) I, III and IV

6. Granulocytes and agranulocytes are the two main categories of :-

(1) RBC (2) WBC (3) Thrombocyte (4) Blood platelets

7. I. Neutrophils II. Eosinophils III. Basophils IV. Lymphocytes

V. Monocytes

Identify whether the given cell types are granulocytes (A) and agranulocytes (B) and choose the correct option accordingly :-

	A	**B**
(1)	I, II, III	IV, V
(2)	I, III, IV	II, V
(3)	IV, V	I, II, III
(4)	II, V	I, III, IV

8. Lymphocytes (20-25%) are of two major types B and T forms. They are responsible for :-

(1) Blood coagulation (2) Thickness of blood

(3) Immune responses (4) All of these

9. Platelets are :-

(1) Also called thrombocytes (2) Cell fragments

(3) Produced from megakaryocytes (4) All of the above

10. Most abundant leucocytes are :-

(1) Lymphocytes (2) Monocytes (3) Neutrophils (4) Acidophils

11. Which of the following is not a granulocytes?

(1) Acidophil (2) Basophil (3) Neutrophil (4) Monocyte

12. Heparin is synthesised by :-

(1) Acidophil (2) Neutrophil (3) Basophil (4) Monocyte

13. Antibodies are produced by :-

(1) T-lymphocytes (2) B-lymphocytes (3) Monocytes (4) Eosinophils

14. Which of the following are derived from megakaryocyte cells of bone marrow?

(1) RBCs (2) WBCs (3) Platelets (4) All of these

15. Normal platelets count is :-

(1) 5 – 5.5 million/mm^3 of blood (2) 6000 – 8000 /mm^3 of blood

(3) 1.5 – 3.5 lakh/mm^3 of blood (4) 0.5 – 1.5 lakh/mm^3 of blood

16. Decrease in number of blood platelets is called :-

(1) Thrombocytopenia (2) Leucocytosis

(3) Leukocytopenia (4) Anaemia

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3. Blood Group :

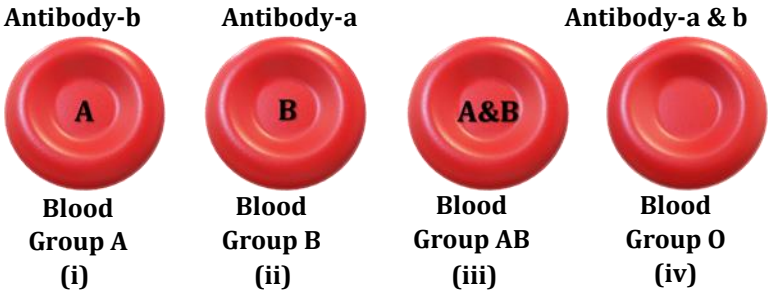
- The blood of all human appears similar but yet differ in certain aspects.
- **ABO system** and **Rh** factors are taken into consideration.

(A) ABO System :

- A, B, O system discovered by **Karl Landsteiner**.
- The type of blood group depends on the type of **antigen** or **Agglutinogen** (Chemicals induce immune response), which are **two types A & B**. These **antigens** are **present on the wall of RBC**.
- Two types of **antibodies** or **Agglutinin** (Proteins produced in response to antigen)**- a/A, b/B** are also found in the **plasma in the blood**.

There are four types of blood groups :

- The blood of a donor has to be **carefully matched** with the blood of a recipient before any **blood transfusion** to avoid severe problems of **clumping (destruction of RBC)**.



- During blood transfusion, the antibodies of receiver attack on antigens of donor if these are same. This may cause severe complications and death of the receiver.
  e.g. **(i)** Antigen A + Antibody A = death of person due to clumping of RBCs.
  (ii) Antigen B + Antibody B = death of person due to clumping of RBCs.

Blood groups and donor compatibility table

Blood groups	Antigen	Antibody	Receive blood from...	Donate blood to.....
A	A	Anti-B	A, O	A, AB
B	B	Anti-A	B, O	B, AB
AB	A, B	Nil	A, B, AB, O	AB
O	Nil	Anti-A, B	O	A, B, AB, O

- It is evident from the table that **group 'O' blood** can be donated to persons with any other blood group and hence 'O' group individuals are called **'universal donors'**.
- Persons with **'AB' group** can accept blood from persons with AB as well as the other groups of blood, Therefore, such persons are called **'universal recipients'**.

(B) Rh Factor :

- Discovered by Landsteiner & Weiner in Rhesus monkey.
- Rh antigen was also found on the surface of RBC of human (Nearly 80%).
- On the basis of this antigen blood group can be positive (+) or negative (–).
- Rh antibodies are naturally absent.

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Case -I			Case -II	
Blood Group	**Rh-antigen**	**Called as**	**Rh-antigen**	**Called as**
A	Present	A^+	Absent	A^-
B	Present	B^+	Absent	B^-
AB	Present	AB^+	Absent	AB^-
O	Present	O^+	Absent	O^-

- If **receiver is positive** and **donor is negative**, then **transfusion is always safe**.
- If **receiver is negative** and **donor is positive**, then **only first transfusion is safe**.
- **Therefore Blood group O^- is universal donor and AB^+ is a universal recipient (Acceptor).**

RH Factor Incompatibility : Rh antigen is due to dominant gene

MALE	FEMALE	CHILD BIRTH
+	+	Safe
–	–	Safe
–	+	Safe
+	–	Not safe (need counselling) Only first Delivery is safe

Erythroblastosis Foetalis:

- If **mother is Rh^-** & **father is Rh^+** then **offspring** will be **Rh^+**.
- In this **case 1st pregnancy** is completely **successful** due to the **separation of blood** through **placenta**, but at the time 1st delivery **Rh antibody** is **formed in mother's blood** due to **breaking of blood vessels** at the **time of delivery**.
- **Now in subsequent delivery Rh antibodies from the mother (Rh^-ve) can leak into the blood of the foetus (Rh^+ ve) and destroy the foetal RBCs**.
- This could be fatal to the foetus or could cause **severe anaemia and jaundice** to the baby. so in next pregnancy death of foetus will occur in the earlier stage due to agglutination of blood called **erythroblastosis foetalis/HDN (Hemolytic disease of newborn)**.

Treatment: -

To make the second pregnancy safe, medicines like **Rhogam, Rholin, Anti D** etc. are used.

4. Blood Clotting (Coagulation of Blood) :

- Whenever we got hurt by a sharp object bleeding occurs and blood oozes out also called exudation of blood.
- Blood flows from cuts or wounds but after sometimes it stops automatically, it is called clotting of blood.
- Bleeding time – 1 -3 min.
- Clotting time – 2 - 8 min.
- Clot or coagulam formed mainly of a network of threads called fibrins in which dead and damaged formed elements of blood are trapped.
- Fibrins are formed by the conversion of inactive fibrinogens in the plasma by the enzyme thrombin.

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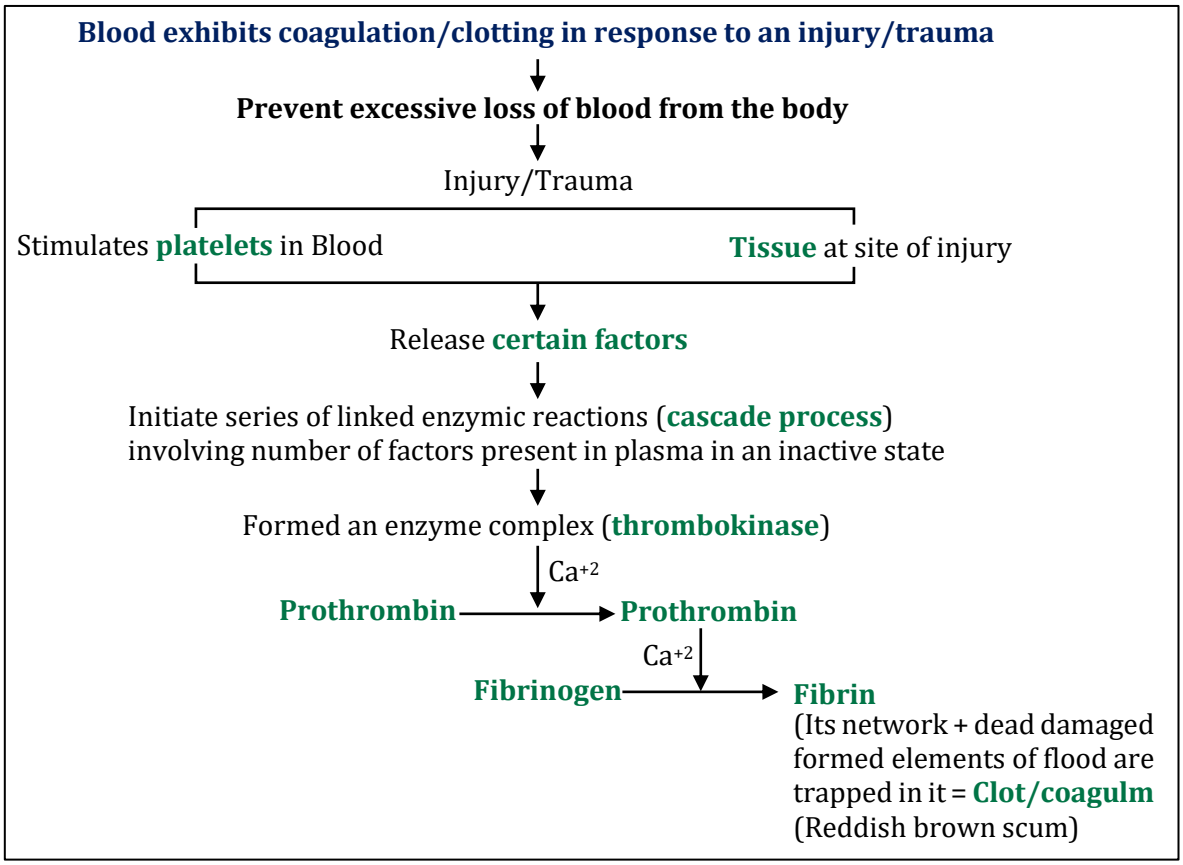
- Thrombins, in turn are formed from another inactive substance present in the plasma called prothrombin. (In presence of vitamin K)
- An enzyme complex, thrombokinase, is required for the above reaction.
- This complex is formed by a series of linked enzymic reactions (cascade process) involving a number of factors present in the plasma in an inactive state.
- An injury or a trauma stimulates the platelets in the blood to release certain factors which activate the mechanism of coagulation.
- Certain factors released by the tissues at the site of injury also can initiate coagulation.
- Calcium ions play a very important role in clotting.


Blood exhibits coagulation/clotting in response to an injury/trauma
Prevent excessive loss of blood from the body
Injury/Trauma
Stimulates platelets in Blood
Tissue at site of injury
Release certain factors
Initiate series of linked enzymic reactions (cascade process) involving number of factors present in plasma in an inactive state
Formed an enzyme complex (thrombokinase)
Ca+2
Prothrombin
Prothrombin
Ca+2
Fibrinogen
Fibrin
(Its network + dead damaged formed elements of flood are trapped in it = Clot/coagulm
(Reddish brown scum)

Blood– Corpuscles = Plasma; Plasma– fibrinogen and large proteins = Serum

Some Natural Anticoagulants :

Heparin	–	Found in vertebrate blood.
Hirudin	–	Found in leech.
Anophelin	–	Found in female Anopheles.
Lampredin	–	Found in Petromyzon.

Artificial Anticoagulants :

To collect blood in bottle or in blood bank artificial anticoagulants are used like-

- Sodium citrate
- Sodium oxalate
- EDTA (Ethylene diamine tetra acetic acid)

These chemicals act as Calcium binding units & remove Ca^{+2} ions from blood.

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Golden Key Points

- **Packed cell volume** (PCV) **:-** % volume or total number of blood corpuscles in blood.
- **Haematocrit Volume :-** % volume or only number of RBC in blood.
- PCV ≈ HV because 99% of packed cell volume is contributed by RBC & in rest 1% WBC & Platelets are present.
- Increase in the RBC count condition is called **polycythemia**. This condition occurs at hill station.
- AB blood group is discovered by De-costello and Sturli.
- In each RBC 26.5 crores molecules of Hb are present.
- Molecular weight of each molecule of haemoglobin – 67,200 Dalton.

BEGINNER'S BOX-3 BLOOD CLOTTING AND BLOOD GROUP

1. Blood clot is mainly due to :-
(1) Fibrin + Corpuscles (2) Heparin + Corpuscles
(3) Plasma + Thrombocytes (4) Plasma + RBC

2. Factors for coagulation or clotting of the blood are present in the ...A... in an ...B... form. Plasma without the clotting factors is called ...C... .
Choose the correct option for the blanks A, B and C :-
(1) A-Plasma, B-inactive, C-serum (2) A-Plasma, B-active, C-serum
(3) A-Plasma, B-inactive, C-lymph (4) A-Plasma, B-active, C-lymph

3. Clotting disorders occur mainly due to the reduction in the number of :-
(1) Granulocytes (2) RBC (3) WBC (4) Platelets

4. Which of the following option describes all the components of human blood :-
(1) Formed elements (2) Plasma
(3) Formed elements and plasma (4) Lymph and Serum

5. Grouping of ABO blood is based on the :-
(1) Surface antigens present on RBCs
(2) Surface lipids present on the cell membrane
(3) Nature of all constituents
(4) Nature of RBC and WBC

6. Choose the correct option for X, Y and Z :-

Blood group	Antigen on RBCs	Antibody in plasma	Donor's Group
A	A	anti b	A, O
B	B	anti A	B, O
AB	X	Nil	Z
O	Nill	Y	O

(1) X-B; Y-A; Z-A, B
(2) X-A, B; Y-Nil; Z-A, B,AB, O
(3) X-A, B; Y-anti-A, B; Z-A, B, AB, O
(4) X-A, B; Y-anti A, B; Z-A, B, AB

7. Blood group which is considered as universal donor :-
(1) Blood group A (2) Blood group B (3) Blood group O (4) Blood group AB

8. The name Rh blood group is derived from :-
(1) Chimpanzee (2) monkey (3) man (4) primitive man

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9. Individuals having Rh antigen are called :-
(1) Rh negative (Rh–ve) (2) Rh positive (Rh+ve)
(3) Rh (±) (4) Rhesus positive

10. Blood without corpuscles and fibrinogen is called :-
(1) Lymph (2) Serum (3) Plasma (4) Platelets

11. Blood group A has: -
(1) Antigen A and antibody B (2) Antigen B and antibody A
(3) Antigens A and B (4) Antibody A and B

12. A person with blood group AB can receive the blood from :-
(1) Blood group A (2) Blood group B (3) Blood group O (4) All of these

13. Universal receiver is :-
(1) Blood group O^+ (2) Blood group O^-
(3) Blood group AB^+ (4) Blood group AB^-

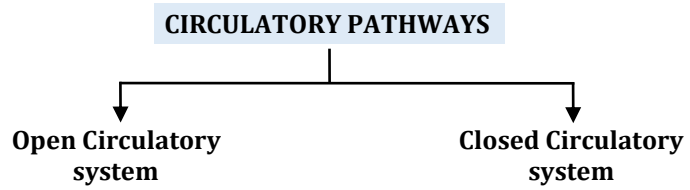
14. In which of the following marriage, couple can face the problem regarding their children?
(1) Male Rh^+ & female Rh^+ (2) Male Rh^- & female Rh^+
(3) Male Rh^+ & female Rh^- (4) Male Rh^- & female Rh^-

15. Fibrinogen is converted into fibrin by :-
(1) Thrombin (2) Prothrombin (3) Heparin (4) Thromboplastin

16. Which of the following is a artificial anticoagulant?
(1) Heparin (2) Hirudin (3) Cumerin (4) EDTA

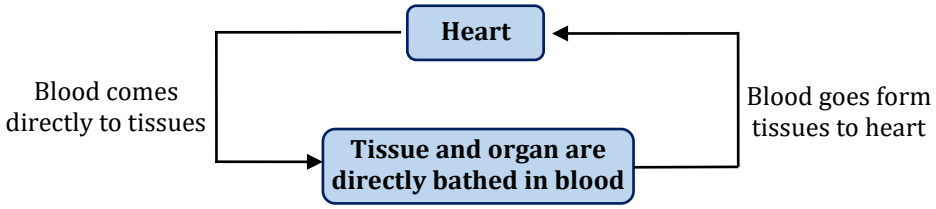
17. Serum differs from plasma as it lacks: -
(1) Albumins (2) Globulins (3) Antibodies (4) Clotting factors

5. Circulatory Pathway :



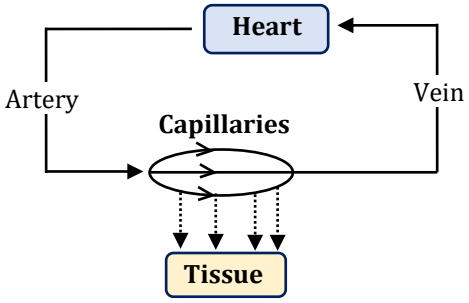
Open Circulatory System :

- The blood or haemolymph is pumped out of the heart and the cells are directly bathed in it.



Examples :-

- Phylum Arthropoda,
- Phylum Mollusca (except cephalopods)
- Phylum Echinodermata
- Lower chordates like Tunicates/urochordates



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Closed Circulatory System :

- The blood is circulated through a series of vessels (arteries, veins and capillaries).

Examples :-

- Phylum Annelida
- Higher Chordates

Comparison between open and closed circulatory system

	Open circulatory system	Closed circulatory system
1.	Blood or haemolymph pumped by heart passes through large vessels into open spaces or body cavities called sinuses.	Blood pumped by the heart circulated through a closed network of blood vessels.
2.	Speed of blood is less	Speed of blood is more
3.	Blood pressure is less	Blood pressure is more
4.	Less efficient	More efficient
5.	Each and every tissue is in direct contact of circulatory fluid	Each and every tissue is not in direct contact with blood
6.	**Examples :-** • Phylum Arthropoda, • Phylum Mollusca (except cephalopods) • Phylum Echinodermata • Lower chordates like Tunicates/ urochordates	**Examples :-** • Phylum Annelida • Higher Chordates • Cephalopods

- Closed circulatory system is considered to be more advantageous as the flow of fluid can be more precisely regulated.

There are Two Types of Blood Circulation :

1. Single circulation

2. Double circulation

Number of Heart chambers and types of circulation in vertebrates :-

	Fishes	Amphibians	Reptiles	Crocodile	Aves	Mammals
No. of heart chambers	2	3	3	4	4	4
Atria	1	2	2	2	2	2
Ventricles	1	1	1	2	2	2
Type of circulation	Single	Transitional Double	Transitional Double	Double	Double	Double

- **In fishes** the heart pumps out deoxygenated blood which is oxygenated by the gills and supplied to the body parts from where deoxygenated blood is returned to the heart (single circulation).
- **In amphibians and reptiles**, except crocodile (has 4 chambers) the left atrium receives oxygenated blood from the gills/lungs/skin and the right atrium gets the deoxygenated blood from other body parts. However, they get mixed up in the single ventricle which pumps out mixed blood (incomplete double circulation or transitional double).
- **In birds, crocodile and mammals**, oxygenated and deoxygenated blood received by the left and right atria respectively passes on to the ventricles of the same sides. The ventricles pump it out without any mixing up, i.e., two separate circulatory pathways are present in these organisms, hence, these animals have double circulation.

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BEGINNER'S BOX-4 TYPES OF BLOOD CIRCULATION

1. Single type of circulation is found in :-
(1) Pisces (2) Amphibians (3) Reptiles (4) Crocodile

2. Closed type of blood circulatory system is found in :-
(1) Frog (2) Snake (3) Human (4) All of these

3. Three chambered heart is found in :-
(1) Fish (2) Frog (3) Rabbit (4) Man

4. Heart of fishes:-
(1) Two chambered (2) Venous heart (3) Both (1) & (2) (4) 3 chambered

5. Circulation in Human is :-
(1) Single & Open (2) Double & Open (3) Double & Closed (4) Single & Closed

6. Which organ receives only oxygenated blood ?
(1) Gill (2) Spleen (3) Lung (4) Liver

7. Open type of circulatory system is found in :-
(1) Arthropoda (2) Echinodermata (3) Mollusca (4) All of these

8. Which animal has most mixing of oxygenated and deoxygenated blood in the ventricles ?
(1) Scoliodon (2) Rabbit (3) Frog (4) Human

9. Closed circulatory system is present in
(1) Annelids and Chordates (2) Arthropods and Annelids
(3) Arthropods and Chordates (4) Molluscs and Annelids

10. Complete double circulation is found in :-
(1) Crocodile (2) Aves (3) Mammals (4) All of these

6. Heart :

Size	Shape	Origin
Clenched fist (12 × 9 × 6 cm)	Pear shaped	Mesodermal

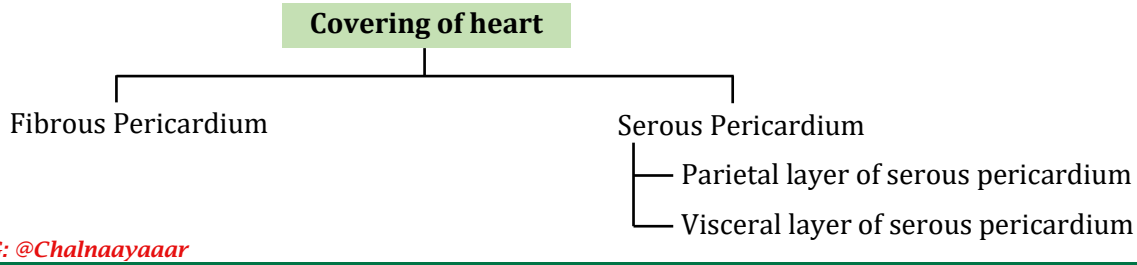
Location :

- Present in thoracic cavity, in space mediastinum (between both the lungs). Heart is **slightly tilted to the left**.

Weight :

- **Adult Male** :- 300 gms.
- **Adult Female** :- 250 gms.
- **Largest heart**- Blue whale.
- **Largest heart in terrestrial animal** - African Elephant

Coverings and Layers of Heart : Heart is protected by a double walled membranous bag.



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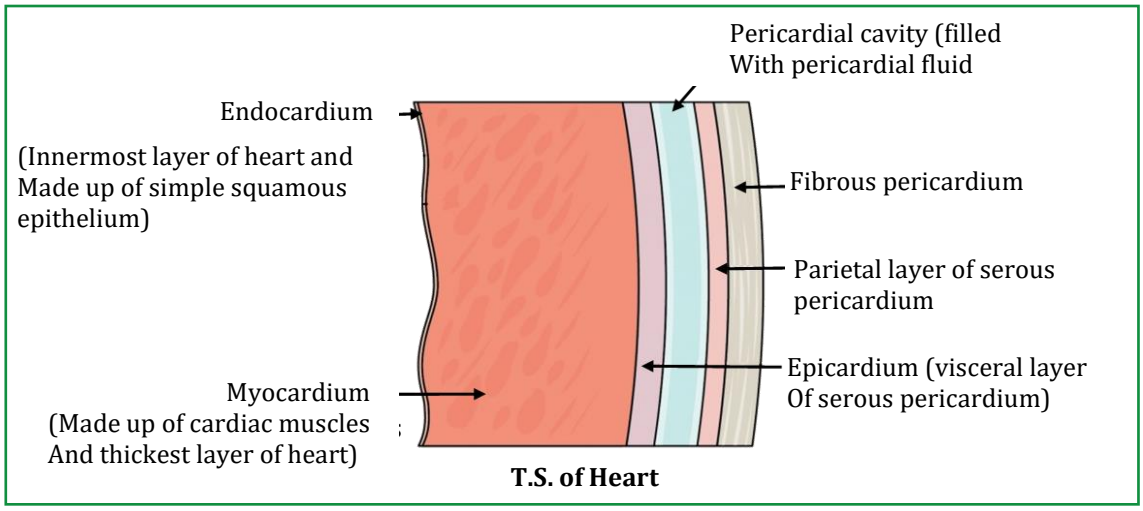
Layers of Heart

		Epicardium	Myocardium	Endocardium
(1)	Layer	Outermost	Middle	Innermost layer
(2)	Origin	Mesodermal	Mesodermal	Mesodermal
(3)	Made up of	Simple squamous epithelium	cardiac muscles which are striated but involuntary	Simple squamous epithelium



T.S. of Heart

Significance of Pericardial Fluid :

- Pericardial fluid act as a shock absorber.
- Pericardial fluid provide frictionless movements between two pericardial membranes .

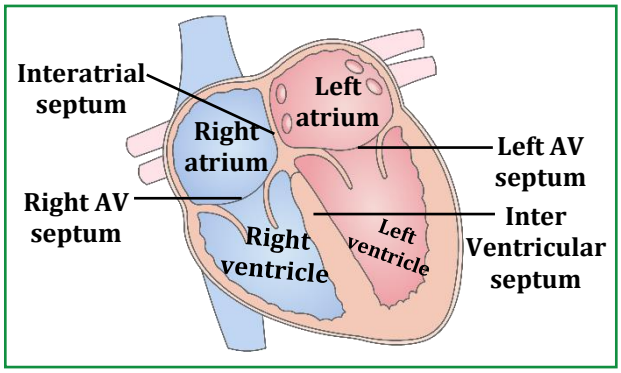
(A) Structure of Heart :

Chambers of Heart :

- Our heart has **four chambers**, two relatively **small upper** chambers called **atria or auricles** and two **larger lower** chambers called **ventricles**.

Septa of Heart :

- A thin, muscular wall called the interatrial septum separates the right and the left atria, whereas a thick-walled, the inter-ventricular septum, separates the left and the right ventricles.
- The atrium and the ventricle of the same side are also separated by a **thick fibrous tissue** called the **atrio-ventricular septum.**
- However, each of these septa are provided with an opening through which the two chambers of the same side are connected.



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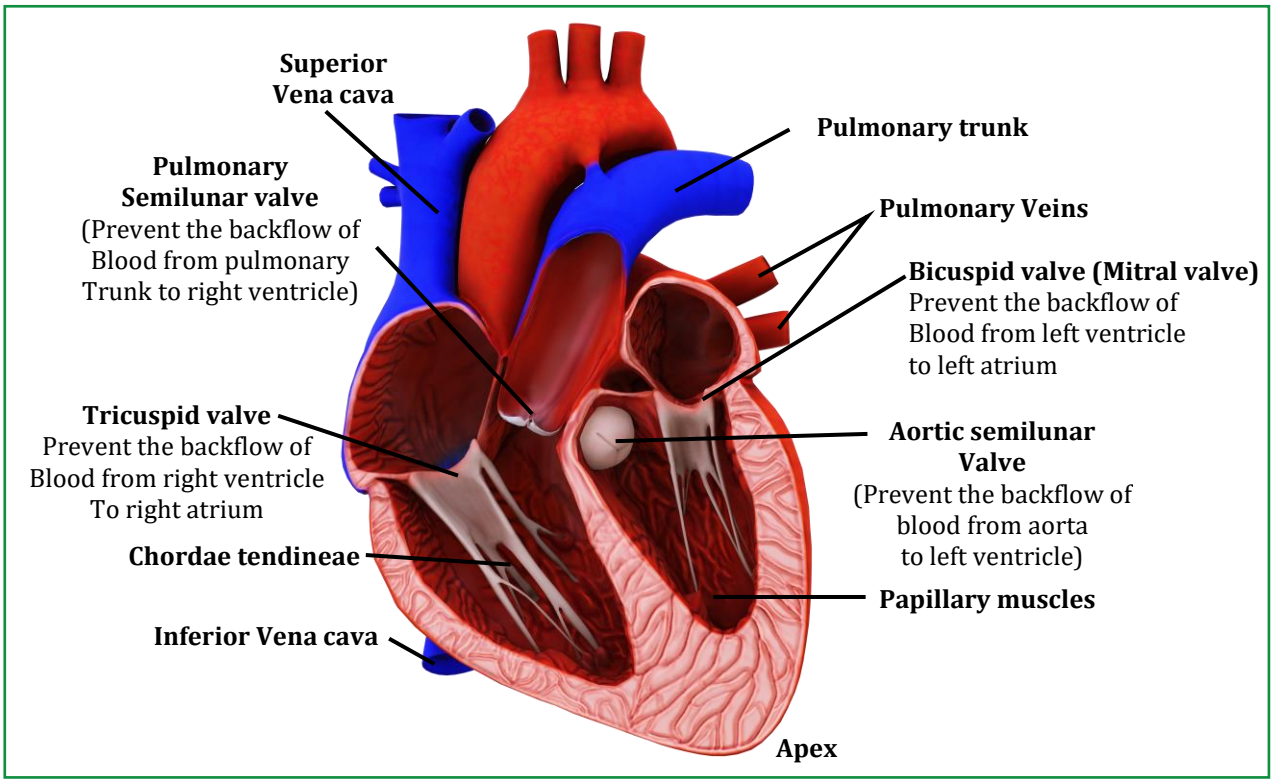
Vessels and Valves of Heart : **The opening between the right atrium and the right ventricle is guarded by a valve formed of three muscular flaps or cusps, the tricuspid valve, whereas a bicuspid or mitral valve guards the opening between the left atrium and the left ventricle**.
The openings of the right and the left ventricles into the pulmonary artery and the aorta respectively are provided with the semilunar valves.

Significance of Valves in Heart : The valves in the heart allows the flow of blood only in one direction, i.e., from the atria to the ventricles and from the ventricles to the pulmonary artery or aorta. These valves prevent any backward flow.

Significance of Chordae Tendinae and Papillary Muscles : Chordae tendinea and papillary muscles prevent the reverse opening of AV valves (Tricuspid and bicuspid) at the time of ventricular systole (contraction of ventricles).


Superior Vena cava
Pulmonary trunk
Pulmonary Semilunar valve
(Prevent the backflow of Blood from pulmonary Trunk to right ventricle)
Pulmonary Veins
Bicuspid valve (Mitral valve)
Prevent the backflow of Blood from left ventricle to left atrium
Tricuspid valve
Prevent the backflow of Blood from right ventricle To right atrium
Aortic semilunar Valve
(Prevent the backflow of blood from aorta to left ventricle)
Chordae tendineae
Papillary muscles
Inferior Vena cava
Apex

Golden Key Points

- Total number of valves in human embryonic heart are six - Tricuspid, bicuspid, pulmonary semilunar, aortic semilunar, Thebasian and Eustachian. Thebasian and eustachian valves merge into the musculature of their respective veins after birth.
- In embryonic heart small opening, foramen ovale is present at interatrial septum which after birth is modified to fossa ovalis.
- In embryonic heart a small duct, ductus arteriosus is present which connect pulmonary artery and aorta, which after birth is modified to ligamentum arteriosum.

BEGINNER'S BOX-5 STRUCTURE OF HEART

1. Tricuspid valve is present :-
(1) between right atrium & right ventricle (2) between left atrium & left ventricle
(3) at the opening of aorta (4) at the opening of coronary sinus

2. Chordae tendinae are found in :-
(1) Ventricles of brain (2) Ventricles of heart
(3) Atria of heart (4) Connection between bone

3. Which has the thickest wall ?
(1) Right auricle (2) Left auricle (3) Right ventricle (4) Left ventricle

4. Total number of valves in human heart :-
(1) two (2) three (3) four (4) Six

5. Opening of the right ventricle to the pulmonary artery and left ventricle to the aorta is provided with :-
(1) Bicuspid valve (2) Tricuspid valve
(3) Semilunar valve (4) All of these

6. The wall of the ventricles are much thicker than that of atrium because :-
(1) It has to pump the blood (2) It has to receive the blood
(3) It is present below the atrium (4) It has to store the blood

7. Mitral valve is present :-
(1) between right atrium & right ventricle (2) at the opening of aorta
(3) between left atrium & left ventricle (4) at the opening of coronary sinus

8. If bicuspid is not working properly then :-
(1) Blood will go back to the right atrium
(2) Supply of blood to the lungs will be reduced
(3) Supply of blood to the body will be reduced
(4) Supply of blood in pulmonary artery will be reduced

9. Which of the following chamber of heart receive deoxygenated blood from vena cava?
(1) Left atrium (2) Right atrium (3) Left ventricle (4) All of the above

(B) Conducting System of Heart :

Types of HEART on the basis of source of Heart Beat

Neurogenic Heart	Myogenic Heart
Heart beat is entirely controlled by nervous supply	Heart beat originates from a muscular tissue. Such heart is called as myogenic heart (Auto excitable heart).
Example : Arthropods and some annelids	**Example :** Mollusca and vertebrates

- The entire heart is made of cardiac muscles. The walls of ventricles are much thicker than that of the atria because ventricles have to supply blood to various parts of the body.
- A specialised cardiac musculature called the nodal tissue is also distributed in the heart. A patch of this tissue is present in the right upper corner of the right atrium called the **sino-atrial node** (SAN).

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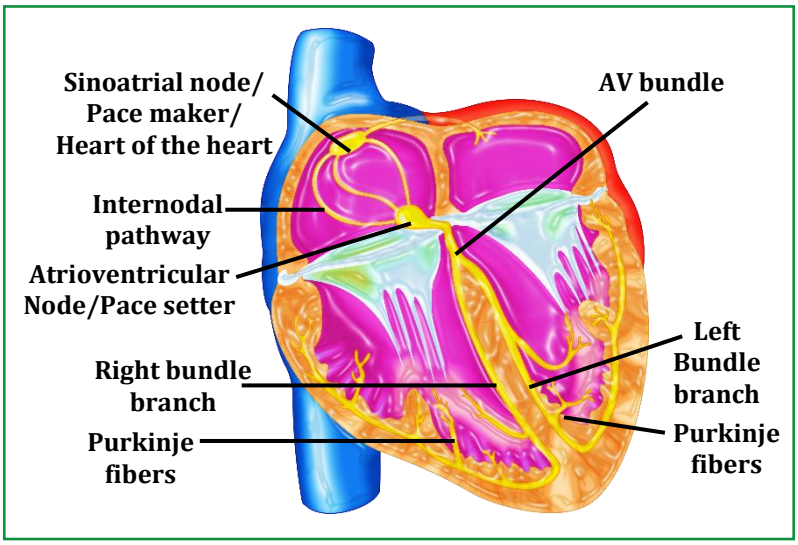
- Another mass of this tissue is seen in the lower left corner of the right atrium close to the atrio-ventricular septum called the **atrio-ventricular node** (AVN).
- Three bundles of muscle fibres connect AV node and SA node called internodal pathways.
- A bundle of nodal fibres, atrioventricular bundle (AV bundle) continues from the AVN which passes through the atrio-ventricular septa to emerge on the top of the interventricular septum and immediately divides into a right and left bundle.
- These right and left bundles with AV bundle are known as bundle of HIS.



- These branches give rise to minute fibres throughout the ventricular musculature of the respective sides and are called purkinje fibres.
- These fibers along with right and left bundle branches are called His - Purkinje system.
- The nodal musculature has the ability to generate action potentials without any external stimuli, i.e., it is auto excitable. Our heart normally beats 70-75 times in a minute (average 72 beats/minutes.
- **SA node (Pacemaker of heart) (Generate maximum number of action potentials i.e., 1 to 72 beats perminute.**
- Atrio-ventricular node (AVN). Present at lower left corner of the right atrium close to the (atrio-ventricular septum) (Reserve pacemaker of heart) (Pacesetter of heart).

Correct Pathway :

SA node → Inter nodal pathway → AV node → AV bundle → Bundle branches → Purkinje fibres

Number of Beats Per Minute :

- SA Node 70-75
- AV Node 40-60
- Purkinje fibres 20-35

(C) Regulation of Cardiac Activity :

- Normal activities of the heart are regulated intrinsically, i.e., auto regulated by specialised muscles (nodal tissue), hence the heart is called myogenic.
- A special neural centre in the medulla oblongata can moderate the cardiac function through autonomic nervous system (ANS).
- Neural signals through the sympathetic nerves (part of ANS) can increase the rate of heart beat, the strength of ventricular contraction and thereby the cardiac output.

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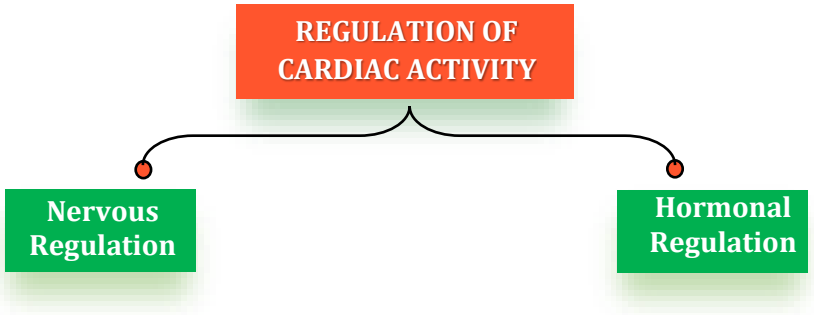

- On the other hand, parasympathetic neural signals (another component of ANS) decrease the rate of heart beat, speed of conduction of action potential and thereby the cardiac output.
- Adrenal medullary hormones can also increase the cardiac output.

Nervous regulation

It is controlled through **Autonomic Nervous System**.

Medulla has cardiac centre

Cardiac Accelerating Centre	**Cardiac Inhibitory Centre**
Releases nor-epinephrine	Releases acetylcholine
Increases Heart beat	Decreases Heart beat
Strength of Ventricular contraction increases	Strength of Ventricular contraction decreases
Increases the cardiac output	Decreases the cardiac output

Hormonal regulation

Hormonal Regulation

Adrenaline/ Epinephrine | **Nor-adrenaline/ Nor-epinephrine** | **Thyroxine**

BEGINNER'S BOX-6

CONDUCTING SYSTEM OF HEART , REGULATION OF CARDIAC ACTIVITY

1. Which of the following is called pacemaker of heart?
(1) SA node (2) AV node (3) AV bundle (4) Purkinje fibers

2. Reserve pacemaker of heart is :-
(1) AV node (2) SA node (3) AV bundle (4) Purkinje fibers

3. Choose the correct pathway of the transmission of impulses in the heart beat :
(1) AV node → S A node → Bundle of His → Purkinje fibres
(2) SA node → AV node → Bundle of His → Purkinje fibres
(3) SA node → Bundle of His → AV node → Purkinje fibres
(4) AV node → Bundle of His → SA node → Purkinje fibres

4. Myogenic heart is found in :-
(1) Pisces (2) Amphibians (3) Reptiles (4) All of these

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5. Which nodal fibres lies along the right and left ventricles ?
(1) AV bundle (2) Purkinje fibre
(3) Neural tissue (4) Cardiac tissue fibre

6. Heart beat is accelerated by :-
(1) sympathetic nerve and acetylcholine both
(2) cranial nerves and adrenaline both
(3) cranial nerves and acetylcholine both
(4) sympathetic nerves and nor epinephrine

7. Pacemaker is :-
(1) Instrument for measuring the heart beat
(2) Instrument for measuring the pulse beat
(3) AV node that provides impulse for the heart beat
(4) Sino atrial node that provides impulse for the heart beat

8. Heart of human is :-
(1) Myogenic (2) Neurogenic (3) 3 chambered (4) All the above

9. Parasympathetic nervous system :-
(1) decreases heart beat (2) increases heart beat
(3) starts heart beat (4) has no effect on heart beat

10. The strength of ventricular contraction increases when SA node is stimulated by :-
(1) vagus nerve (2) parasympathetic nerves
(3) sympathetic nerves (4) all of the above

(D) Cardiac Cycle :

- **One complete rhythmic relaxation and contraction of all the part of the heart which result in receiving and pumping of the blood.**

Contraction → Systole **Relaxation → Diastole**

Cardiac Cycle Mechanism :

How does the heart function?

- To begin with, all the four chambers of heart are in a relaxed state, i.e., they are in joint diastole.
- As the tricuspid and bicuspid valves are open, blood from the pulmonary veins and vena cava flows into the left and the right ventricle respectively through the left and right atria.
- The semilunar valves are closed at this stage.
- The SAN now generates an action potential which stimulates both the atria to undergo a simultaneous contraction - the atrial systole. This increases the flow of blood into the ventricles by about 30 per cent.
- The action potential is conducted to the ventricular side by the AVN and AV bundle from where the bundle of His transmits it through the entire ventricular musculature. This causes the ventricular muscles to contract, (ventricular systole), the atria undergo relaxation (diastole), coinciding with the ventricular systole.
- Ventricular systole increases the ventricular pressure causing the closure of tricuspid and bicuspid valves due to attempted backflow of blood into the atria.

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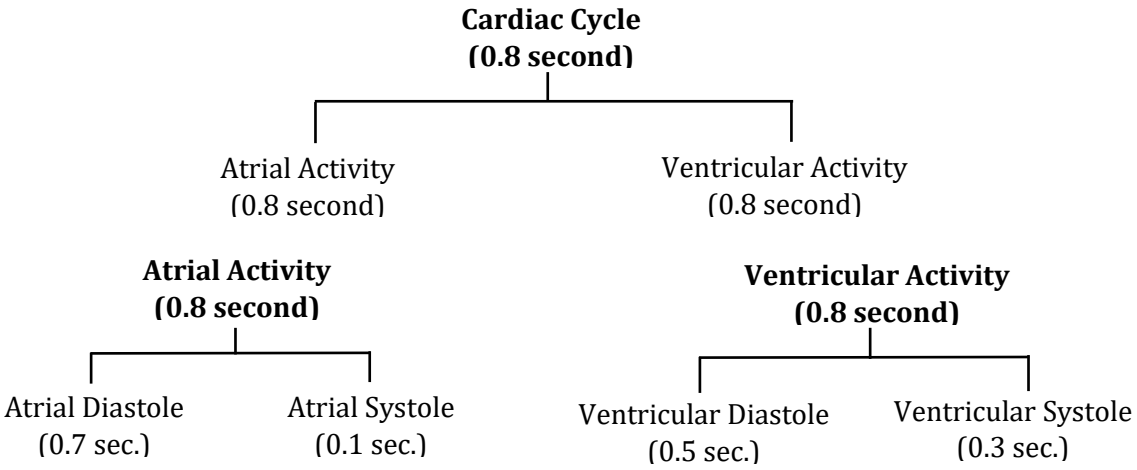
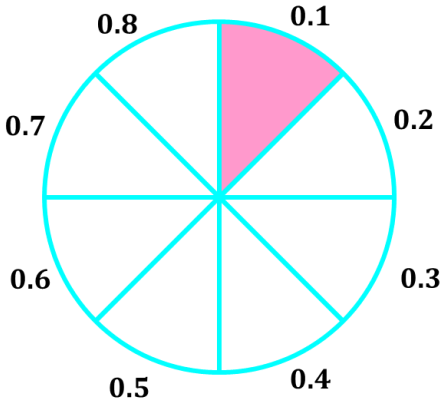
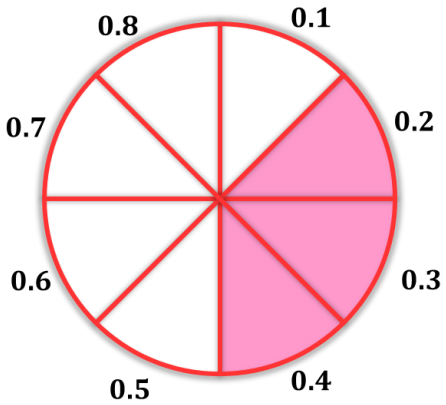
- As the ventricular pressure increases further, the semilunar valves guarding the pulmonary artery (right side) and the aorta (left side) are forced open, allowing the blood in the ventricles to flow through these vessels into the circulatory pathways.
- The ventricles now relax (ventricular diastole) and the ventricular pressure falls causing the closure of semilunar valves which prevents the backflow of blood into the ventricles. As the ventricular pressure declines further, the tricuspid and bicuspid valves are pushed open by the pressure in the atria exerted by the blood which was being emptied into them by the veins. The blood now once again moves freely to the ventricles.
- The ventricles and atria are now again in a relaxed (joint diastole) state, as earlier. Soon the SAN generates a new action potential and the events described above are repeated in that sequence and the process continues.
- This sequential event in the heart which is cyclically repeated is called the cardiac cycle and it consists of systole and diastole of both the atria and ventricles.
- There are 72 cardiac cycle/minutes in an adult.
- Duration of cardiac cycle = 60/72 = 0.8 sec.



Atrial Activity (0.8 second) :



Ventricular Activity (0.8 second) :



- **Combinedly :**
  Outer circle - **Atria**
  Inner circle - **Ventricles**

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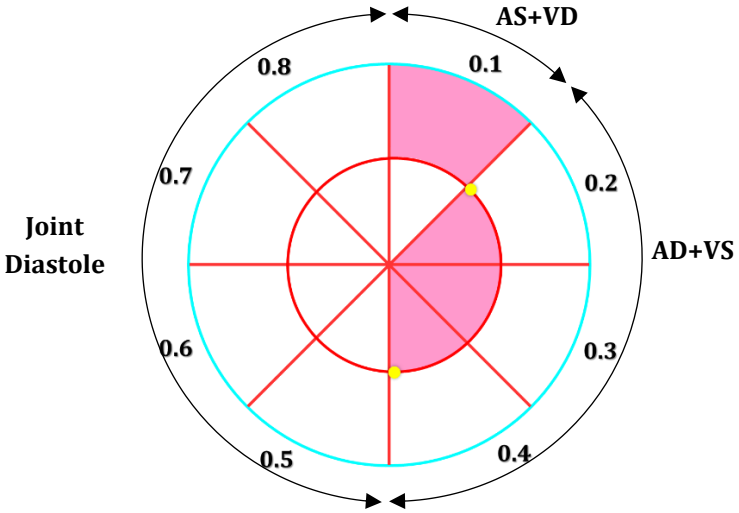

- **End Diastolic Volume (EDV) = 120 ml.**
- **End Systolic Volume (ESV) = 50 ml.**
- **Stroke Volume (SV) = EDV – ESV = 120 - 50 = 70 ml.**
- **Stroke Volume (SV) =** Amount of blood pumped by each ventricle in one cardiac cycle, it is generally **70 ml**.
- **Cardiac Output = SV × Number of beats/min.**
  = 70 ml × 72 beats /min.
  = 5 L/min at rest
- **Formula for calculating time of cardiac cycle = 1 / heart beat per minute**
- Therefore, the cardiac output can be defined as the volume of blood pumped out by each ventricle per minute and averages 5040 mL or 5 litres in a healthy individual.
- **Amount of blood present in each ventricle at the end of one ventricular diastole is called end diastolic volume.**
- **Amount of blood present in each ventricle at the end of one ventricular systole is called end systolic volume.**
- **Blood enters into the heart because muscles of atria relax.**
- **Blood leaves out of the heart because muscles of ventricles contract.**
- The body has the ability to alter the stroke volume as well as the heart rate and thereby the cardiac output. For example, the cardiac output of an athlete will be much higher than that of an ordinary man.

Heart Beat :

- **Rhythmic pulsation of musculature of the heart is called heart beat.**
- **Human Adults: 72**
- **New Born Baby: >120**

Pulse :

- **Pulse is tactile arterial palpation occurs due to cardiac cycle.**
- **Pulse is easily felt in radial artery of wrist and carotid artery of neck.**
- **Number of pulse = Number of cardiac cycle.**

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(E) Heart Sounds :

- During each cardiac cycle two prominent sounds are produced which can be easily heard through a stethoscope.
- The **first heart sound (Lub)** is associated with the **closure of the tricuspid and bicuspid valves**.
- The second heart sound (Dub) is associated with the closure of the semilunar valves.
- These sounds are of clinical diagnostic significance.

	LUB	DUB
1.	dull, prolonged (0.15 sec)	sharp, shorter timed, high pitch (0.1 sec)
2.	At the beginning of ventricular systole	At the beginning of ventricular diastole
3.	Caused by closure of AV valves	Caused by closure of Semilunar valves

*** Murmur - Defective heart sound due to defects in heart valves.**

(F) Double Circulation :

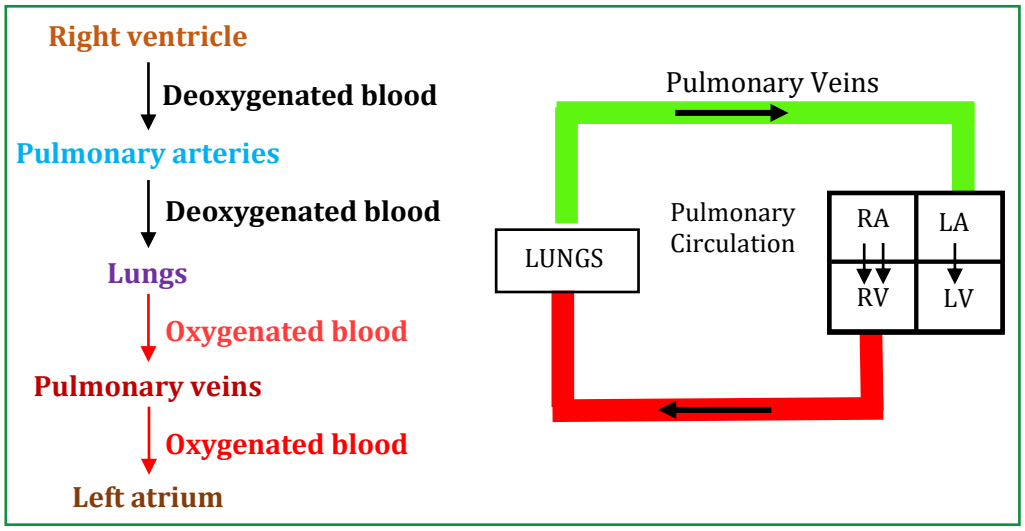
- There are two types of circulation of blood taking place in heart.

  (i) Pulmonary Circulation

  (ii) Systemic Circulation

(i) Pulmonary Circulation :

- The deoxygenated blood pumped into the pulmonary artery is passed on to the lungs from where the oxygenated blood is carried by the pulmonary veins into the left atrium. This pathway constitutes the pulmonary circulation.
- **Significance of pulmonary circulation:-** Supply deoxygenated blood to lungs for oxygenation and collect oxygenated blood from lungs



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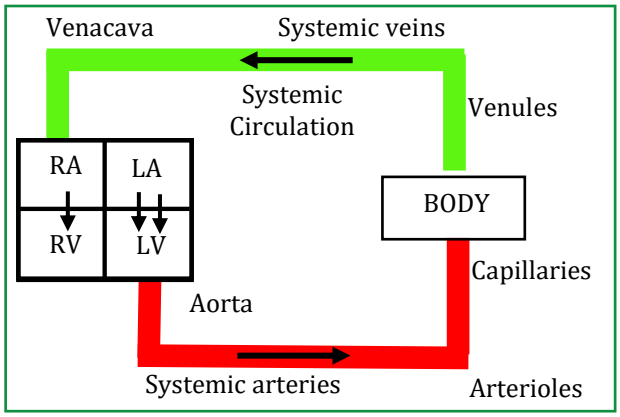
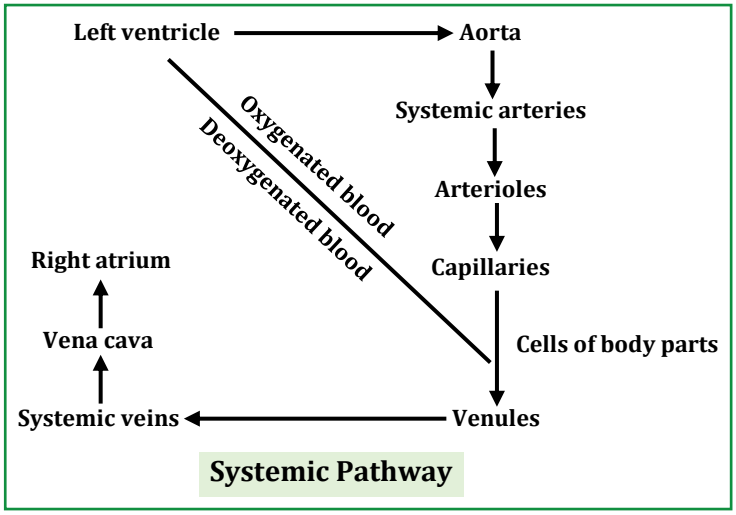
(ii) Systemic Circulation :

- The oxygenated blood entering the aorta is carried by a network of arteries, arterioles and capillaries to the tissues from where the deoxygenated blood is collected by a system of venules, veins and vena cava and emptied into the right atrium. This is the systemic circulation.

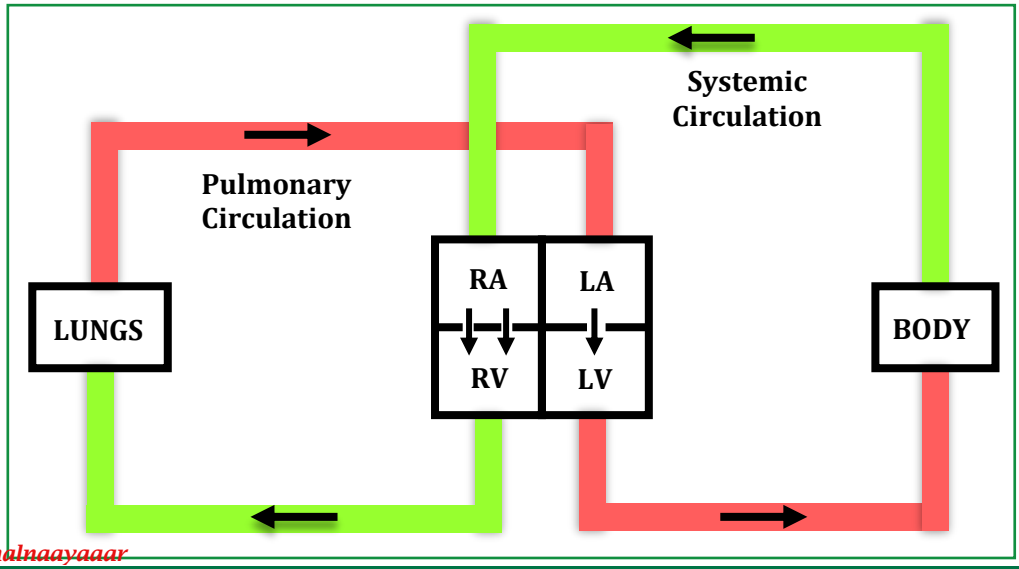


Significance of Systemic circulation : Supply oxygen and nutrients to various parts of body and collect carbon dioxide and waste materials from different parts of body.



Double Circulation :

- Pulmonary circulation and Systemic circulation collectively called as **"Double circulation"** .
- In double circulation blood as to pass heart twice once in right part of heart then goes to lungs for oxygenation and come back to left side of the heart.



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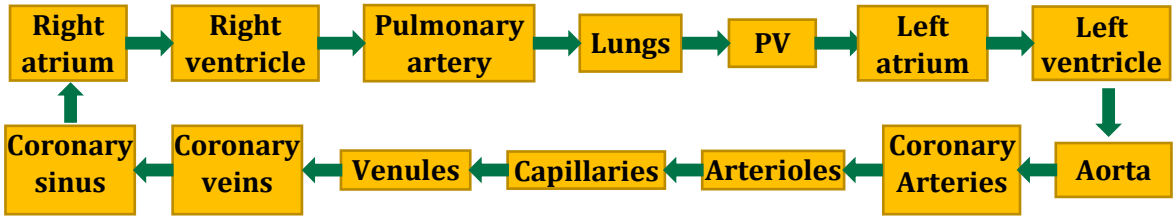
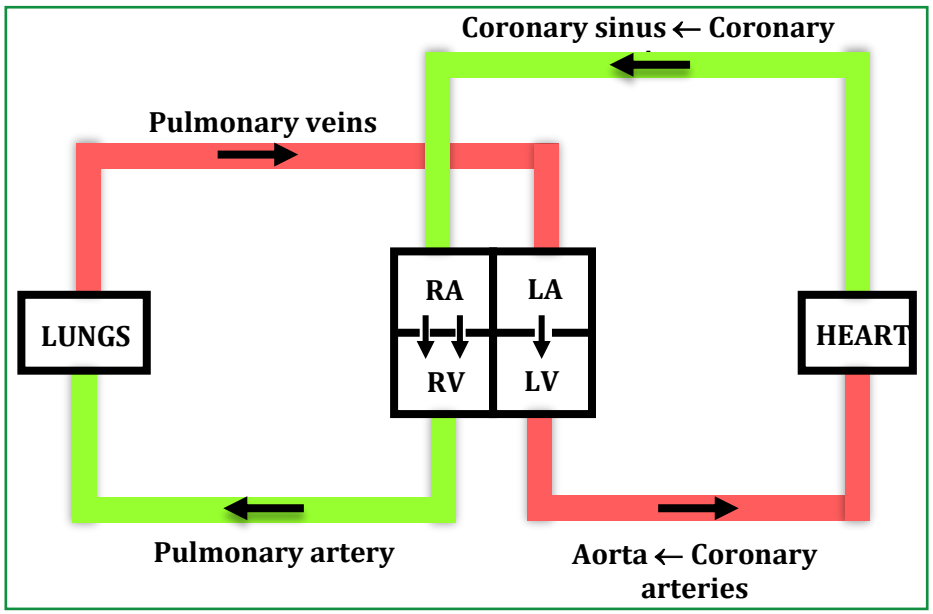
On the basis of supply to the organ circulation is of various types :

- For Brain – Cerebral Circulation
- For Kidneys – Renal Circulation
- For Heart – Coronary Circulation
- For liver – Hepatic Circulation

Coronary Circulation :

A special coronary system of blood vessels is present in our body exclusively for the circulation of blood to and from the cardiac musculature.





BEGINNER'S BOX-7 — CARDIAC CYCLE AND HEART SOUNDS

1. Contraction of heart is called :-
(1) peristalsis (2) systole (3) diastole (4) voluntary contraction

2. First heart sound is :-
(1) Lub sound at the end of atrial systole -
(2) Lub sound at the beginning of ventricular systole
(3) Dub sound at the end of systole
(4) Dub sound at the beginning of ventricular systole

3. Normal Cardiac output is :-
(1) 15 Litres/min. (2) 5 Litres × 72/min. (3) 5 Litres/min. (4) 5/72 Litres/min.

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4. The amount of blood that actively flows from atria to ventricles in human is :-
(1) 25% to 30% (2) 35% to 45% (3) 70% to 78% (4) 90%

5. Cardiac output is determined by
(1) Heart rate (2) Stroke volume (3) Blood flow (4) Both 1 and 2

6. Cardiac output is blood :-
(1) received by heart per minute
(2) pumped by ventricles per sec
(3) pumped by left ventricle per minute
(4) pumped by left ventricle per hour

7. The 'Lub' and 'Dub' heart sound are due to :-
(1) Opening of heart valves (2) Action of papillary muscles
(3) Closing of heart valves (4) Activity of pace maker

8. I^{st} Heart Sound is due to :
(1) Closure of Semilunar valve
(2) Closure of Pulmonary & Aortic Valve
(3) Vibration just after Closure of Mitral & Tricuspid valve
(4) Vibration after Closure of Pulmonary & Aortic Valve

9. Atrial diastole takes place when :-
(1) Right atrium is filled with blood
(2) Left atrium is filled with blood
(3) Both atria are filled with blood
(4) Both ventricles are filled with blood

10. When two atria contract simultaneously and results in the blood pumping into ventricles, this is called :-
(1) Atrial diastole (2) Atrial systole
(3) Ventricular diastole (4) Ventricular systole

11. Blood circulation take following course in heart of man :-
(1) Left atrium - left ventricle - body organ - right atrium - right ventricle
(2) Right atrium - left ventricle
(3) Left atrium - left ventricle - lungs-right atrium - right ventricle
(4) Right atrium - left atrium - left ventricle - right ventricle - body parts

12. To reach the left side of heart the blood must pass through :-
(1) Sinus venosus (2) Kidneys (3) Liver (4) Lungs

13. When the right ventricle contracts the blood is pump in to :-
(1) superior vena cava (2) dorsal aorta
(3) pulmonary aorta (4) pulmonary veins

14. The blood leaving the lungs is richer than the blood entering the lung in :-
(1) oxygen (2) carbon dioxide (3) hydrogen (4) moisture

15. Double circulatory system means that blood :-
(1) passes through two chambers
(2) passes two times through heart
(3) passes through one chamber
(4) All of the above

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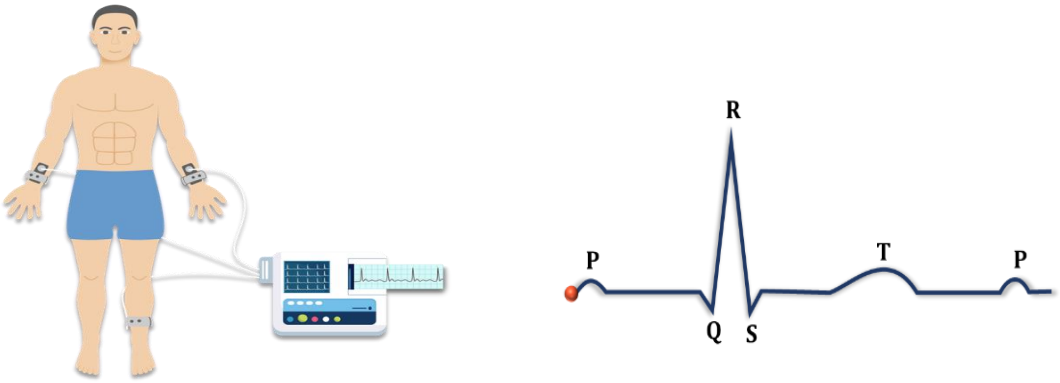
7. Electrocardiograph (ECG) :

- ECG is a graphical representation of the electrical activity of the heart during a cardiac cycle.
- ECG stands for **Electrocardiogram**.
- Developed by **Willem Einthoven**
- Device used is **Electrocardiograph**.
- To obtain a standard ECG (as shown in the Figure), a patient is connected to the machine with **three electrical leads (one to each wrist and to the left ankle)** that continuously monitor the heart activity.
- For a detailed evaluation of the heart's function, multiple leads are attached to the chest region.
- In standard ECG, each peak in the ECG is identified with a letter from P to T that corresponds to a specific electrical activity of the heart.



ECG is the record of electrical activities in different part in the heart during cardiac cycle.

Details of different waves in ECG :

Wave	What it corresponds
P wave	Represents depolarization of atria, which leads to contraction of both the atria.
QRS complex	Represents depolarization of ventricles, which leads to contraction of both the ventricles.
T wave	• Represents repolarization of ventricles, which leads to relaxation of both the ventricles. • The end of the T-wave marks the end of systole

- **By counting the number of QRS complexes that occur in a given time period, one can determine the heart beat rate of an individual.**

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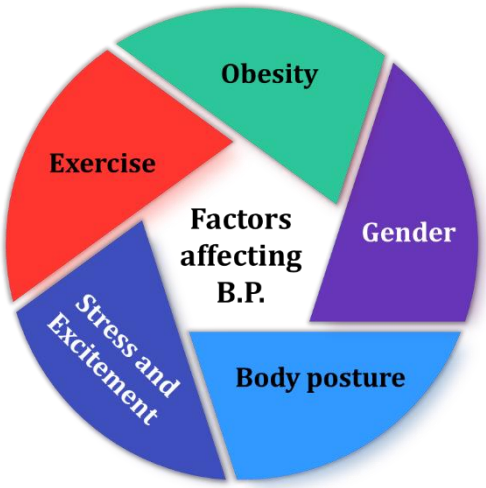
Significance of ECG :

- ECG is of a great clinical significance as any **deviation from this shape indicates a possible abnormality or disease.**

8. Blood Pressure :

- Blood pressure is the pressure exerted by the flowing blood on the elastic walls of arteries.
- **Hales** measured B.P. in **horse** first of all.
- The instrument by which we can measure B.P. is called **Sphygmomanometer**.
- Blood-pressure is measured in two stages :-
  (i) Systolic pressure (120 mm of Hg)
  (ii) Diastolic pressure (80 mm of Hg)
- **Normal B.P.** of a healthy person is **120/80 mm Hg**.

Factors Affecting B.P. :



9. Disorders of Circulatory System :

(i) High Blood Pressure :

- Also called as **Hypertension**.
- BP is **140/90 mm of Hg** or higher.

Effects of High B.P. :

- Brain haemorrhage/CVA/Stroke.
- Damage to kidneys and eyes.
- Cardiomegaly (Increase in size of heart).

(ii) Low Blood Pressure :

- Also called as **Hypotension**.
- BP is **110/70 mm of Hg** or less.

Effects of Low B.P. :

- Feeling of sickness.
- Feeling of weakness.
- Confusion and dizziness etc.

(iii) Coronary artery disease :

- Also referred as **Atherosclerosis**.
- Affect the coronary artery of heart.
- **Caused by deposits of calcium, fat, cholesterol and fibrous tissue.**
- **Effects of CAD : Make the lumen of arteries narrower**.

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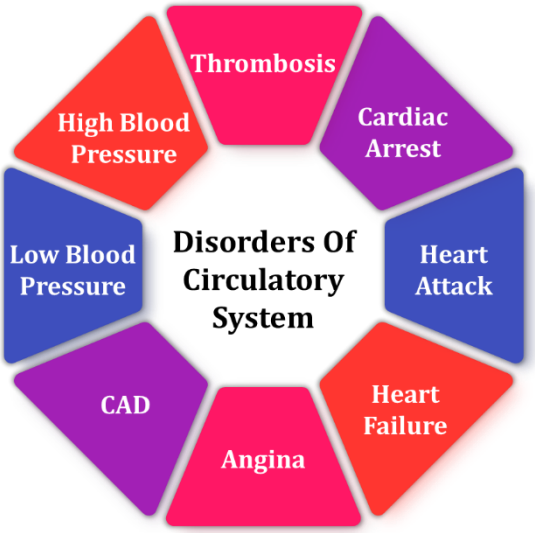
(iv) Angina :

- Also referred as **Angina Pectoris**.
- Affect the muscles of heart.
- **Caused due to reduction in supply of oxygen**.
- More common among the middle-aged and elderly.

Effects of Angina : Acute chest pain.



(v) Heart failure :

- State of the heart it is **not pumping the blood effectively**.

(vi) Heart attack :

- Also called **Myocardial Infarction**.
- **Heart muscles are suddenly damaged due to inadequate blood supply**.

(vii) Cardiac arrest :

- Complete stoppage of cardiac activity/heartbeat.

(viii) Thrombosis :

- It is the formation of a blood clot inside a blood vessel anywhere in body

BEGINNER'S BOX-8 — BLOOD PRESSURE, DISORDERS

1. Atherosclerosis refers to the ailment of :-
(1) Lungs (2) Heart (3) Kidney (4) Liver

2. Which one indicates hypertension or high blood pressure (BP) :-
(1) 120/80 (2) 110/70 (3) 130/80 (4) 140/90

3. Atherosclerosis is called :-
(1) Coronary artery disease (2) Angina
(3) Heart failure (4) Hypertension

4. The disease of heart in which deposit of calcium, fat and others fibrous tissues take place inside the artery is :-
(1) heart failure (2) atherosclerosis (3) angina pectoris (4) murmur

5. Angina occurs due to :-
(1) When enough oxygen is reaching to heart muscle
(2) When not enough oxygen is reaching to heart muscle
(3) The deposition of carbohydrates in artery
(4) The deposition of protein in artery

6. Coronary heart disease is due to the inadequate blood supply to :-
(1) Heart ventricle (2) Heart auricle (3) Heart valves (4) Heart muscles

7. Who developed an Electrocardiogram?
(1) Wilhelm His (2) Steward (3) Hubert Mann (4) Einthoven

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8. In case of a normal heartbeat, depolarization stimulus arises in which of the following?
(1) Epicardium (2) Sinoatrial Node (SA node)
(3) AV values (4) Endocardium

9. What does the T wave represent in an ECG?
(1) Atrial diastole (2) Atrial systole
(3) Ventricular diastole (4) Joint diastole

10. What does the depolarization of ventricles initiate?
(1) Atrial diastole (2) Atrial systole
(3) Ventricular systole (4) Joint diastole

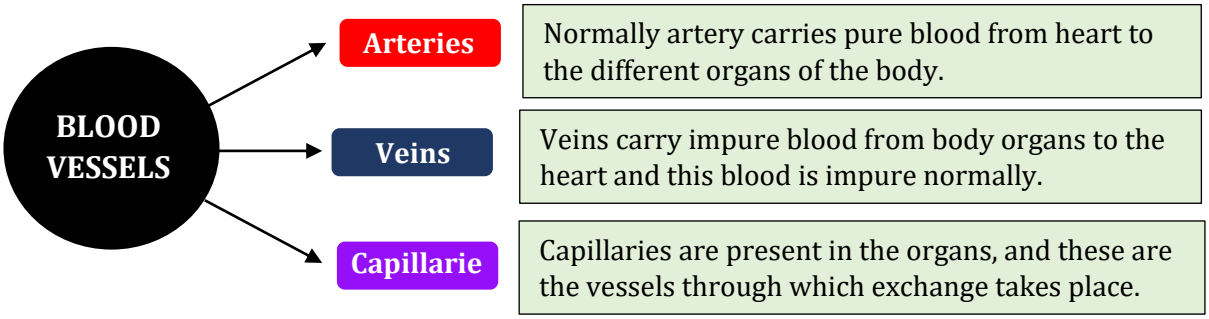
11. When heart beat is decreases then normal is called: -
(1) bradycardia (2) tachycardia (3) hypocardia (4) All of the above

12. When heart is not pumping the blood effectively enough to meet the needs of the body, it is called:
(1) heart failure (2) cardiac arrest (3) heart attack (4) angina

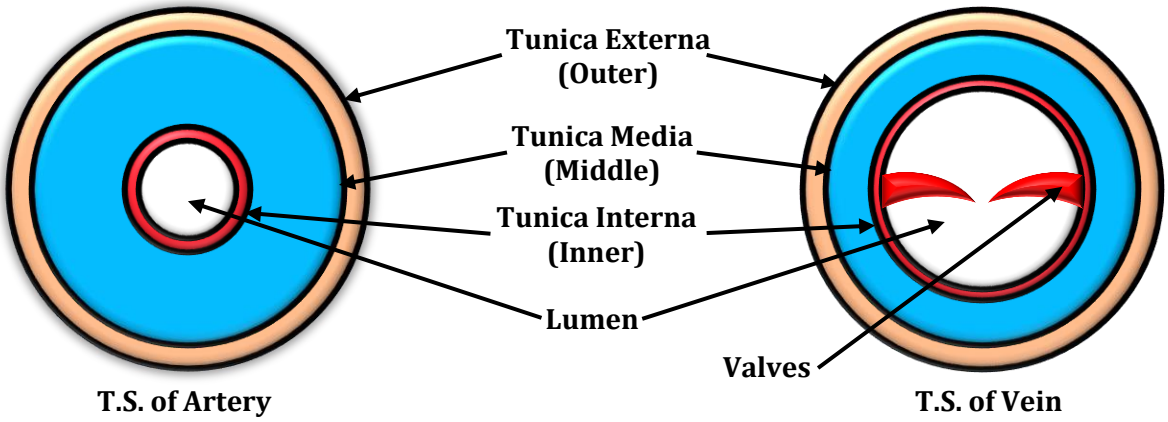
13. Persons suffering from high blood pressure should take the following precautions to avoid rise in their blood pressure :-
(1) Sleep as much as possible (2) Avoid standing
(3) Increase their weight (4) avoid emotional disturbances and excitement

10. Blood Vessels and Lymph :

In closed type of blood vascular system blood vessels are of 3 types :


BLOOD VESSELS
Arteries
Veins
Capillarie
Normally artery carries pure blood from heart to the different organs of the body.
Veins carry impure blood from body organs to the heart and this blood is impure normally.
Capillaries are present in the organs, and these are the vessels through which exchange takes place.

Anatomy of Blood Vessels :



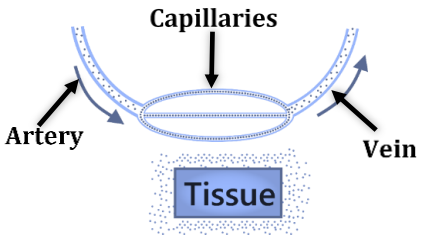
- **Tunica Externa :-** It has loose connective tissue with collagen fibres, elastin fibres and longitudinal smooth muscles.

- **Tunica Media :-** It is a thick layer of circular smooth muscles and a network of elastin fibres.
- **Tunica Interna/ Intima :-** This layer is made up of simple squamous epithelium. It is also known as Endothelium.

Artery	Vein
It carries blood from the heart to the organs.	It carries blood from organs to the heart.
All the arteries carry pure blood except **pulmonary artery** which carries impure blood.	All the veins carry impure blood except **pulmonary vein** which carries pure blood.
Blood flows with a **high pressure & speed**.	In the vein, blood flows with a **low pressure & speed**.
Arteries are deeply situated in the body.	Veins are superficial just below the skin.
The walls of arteries are thick and tough.	The walls of veins are thin and soft.
Lumen is constricted.	Lumen is wide.
Valves are absent in the walls of arteries.	Walls of veins contain valves.
These are pinkish or bright red in colour.	These are deep red or bluish in colour.
Arteries do not collapse when empty, because their walls are thick.	Veins usually collapse when empty.
Their tunica media layer is much thicker as compared to veins.	Their tunica media layer of wall is thinner as compared to arteries.

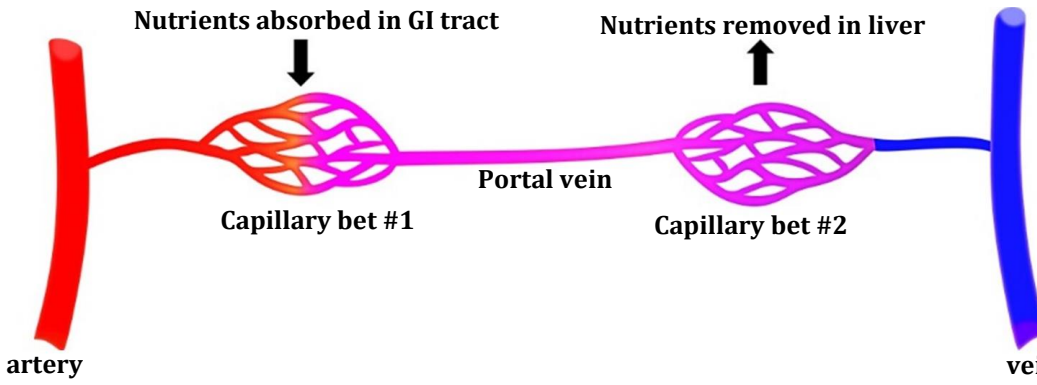
Capillaries :

- These are present between arteries and veins.
- In the walls of blood capillaries only endothelium layer is found. It is made up of simple squamous epithelium.
- Exchange of material between blood and tissue occurs at the level of capillaries.



Portal system :

When the vein of any organ of the body does not open in the caval vein or heart but it divides into capillaries in any other organ and its blood is transported by vein of that other organs to the heart, then this type of system is termed as portal system. or **Blood circulation that starts in capillaries and ends in capillaries is called portal system.**



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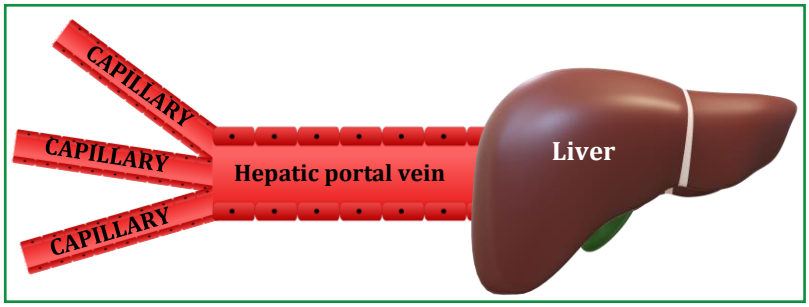
It is of following types:-

I. Renal portal system
II. Hepatic portal system
III. Hypophysial portal system

Hepatic Portal System :

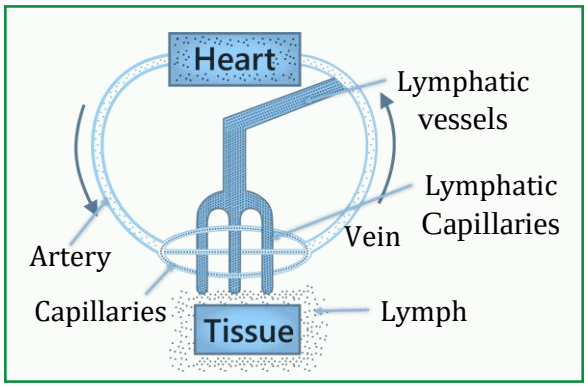
- A unique vascular connection exists between the digestive tract and liver called hepatic portal system. The hepatic portal vein carries blood from intestine to the liver before it is delivered to the systemic circulation.



Lymph :

- Lymph is a colourless fluid which is formed by the filtration of blood at capillaries level.
- Lymph = plasma without large protein + WBCs mainly lymphocytes
- Lymph is also called as tissue fluid or ECF or interstitial fluid.

An elaborate network of vessels called the lymphatic system collects this fluid and drains it back to the major veins and then to the heart finally.



Functions of lymph :

- Lymph acts as 'Middle Man' between blood and tissue,
- Exchange of nutrients, gases, etc., between the blood and the cells always occur through this fluid
- Lymph is also an important carrier for nutrients.
- In intestine, lymph help in absorption of fat through special lymphatic capillaries called lacteals.
- Lymph has lymphocytes therefore responsible for immune responses of the body.

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BEGINNER'S BOX-9 BLOOD VESSELS, PORTAL SYSTEM, LYMPH

1. The correct sequence of layers found in the walls of arteries from inside to outward is :-
(1) Tunica adventitia, tunica interna & tunica media
(2) Tunica interna, tunica externa & tunica media
(3) Tunica interna, tunica media & tunica externa
(4) Tunica media, tunica externa & tunica interna

2. The smallest blood vessel in the body is :-
(1) Capillary (2) Artery (3) Vein (4) Vena cava

3. Filter apparatus for dead R.B.C is :-
(1) Spleen + Kidney (2) Liver + Kidney
(3) Spleen + Liver + Kidney (4) Liver + Spleen

4. In which of the following character a vein differs from an artery :-
(1) Having valves to control flow of blood
(2) Having narrow lumen
(3) Having muscular wall
(4) Having pigmented wall to give dark look

5. If spleen of Human is removed from body then :-
(1) Animal will die
(2) Number of blood platelets will increase
(3) Number of blood platelets will decrease
(4) There will be no effect on the number of blood platelets

6. Which one of the following is the main graveyard of RBC :-
(1) Bone marrow (2) Spleen (3) Liver (4) Kidney

7. Which blood vessel carry blood from the different part of your body to the heart :-
(1) Capillaries (2) Arteries (3) Veins (4) All of these

8. Blood Capillaries are made of :-
(1) Endothelium and thin coat of connective tissue
(2) Endothelium and thin coat of muscle fibres
(3) Endothelium and thin coat of connective tissue and muscle fibres.
(4) Only endothelium

9. All arteries carry oxygenated blood except :-
(1) Systemic artery (2) Hepatic artery
(3) Pulmonary artery (4) Cardiac artery

10. An artery can be distinguished from a vein in having :-
(1) Thicker wall (2) Lesser lumen
(3) No valves (4) All of the above

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BEGINNER'S BOX — ANSWERS KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	1	3	2	4	4	1	2	1	2
	Que.	11	12	13	14	15	16	17	18	19	20
	Ans.	4	4	2	1	4	4	1	4	2	4
	Que.	21									
	Ans.	2									

BEGINNER'S BOX-2	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	4	1	2	2	1	2	1	3	4	3
	Que.	11	12	13	14	15	16				
	Ans.	4	3	2	3	3	1				

BEGINNER'S BOX-3	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	1	4	3	1	3	3	2	2	2
	Que.	11	12	13	14	15	16	17			
	Ans.	1	4	3	3	1	4	4			

BEGINNER'S BOX-4	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	4	2	3	3	2	4	3	1	4

BEGINNER'S BOX-5	Que.	1	2	3	4	5	6	7	8	9
	Ans.	1	2	4	3	3	1	3	3	2

BEGINNER'S BOX-6	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	1	2	4	2	4	4	1	1	3

BEGINNER'S BOX-7	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	2	2	3	1	4	3	3	3	4	2
	Que.	11	12	13	14	15					
	Ans.	1	4	3	1	2					

BEGINNER'S BOX-8	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	1	4	1	2	2	4	4	2	3	3
	Que.	11	12	13							
	Ans.	1	1	4							

BEGINNER'S BOX-9	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	3	1	3	1	4	2	3	4	3	4

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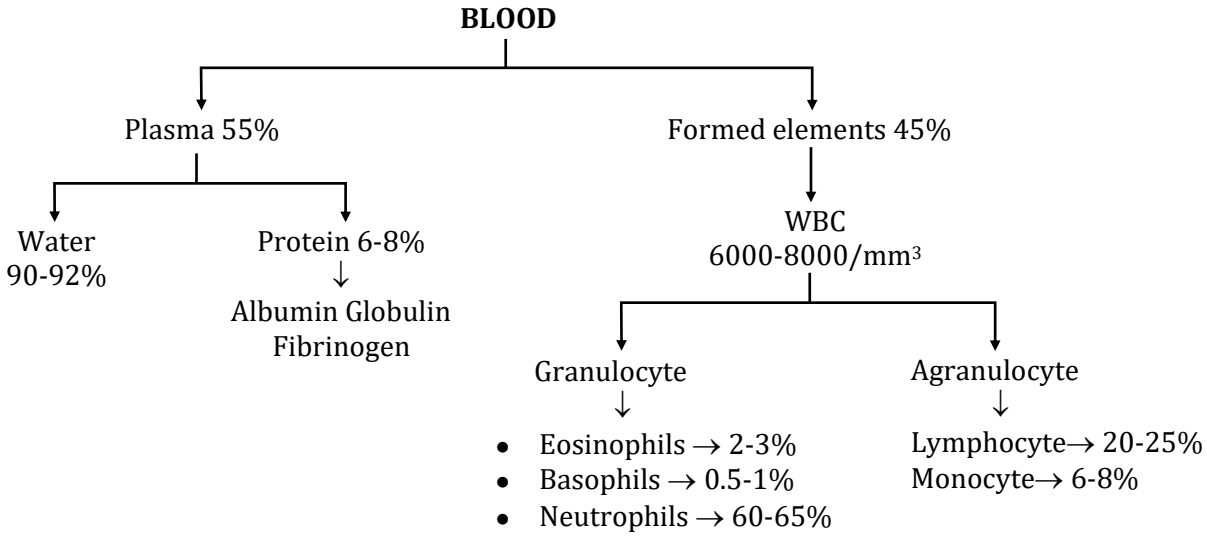
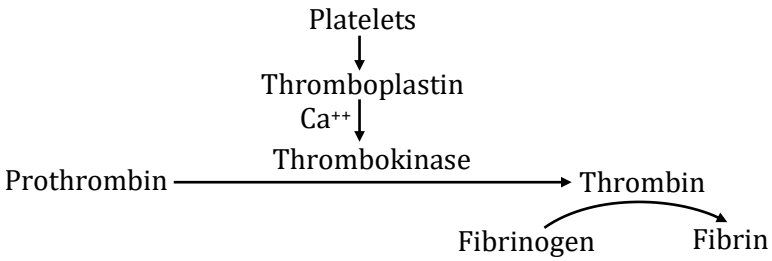


- **Blood Clotting :**



- Blood Groups:
- Universal donor blood group is O.
- Universal acceptor blood group is AB.
- Rh positive person can donate to Rh negative person only once.
- If mother is Rh^- and foetus is Rh^+ then in second pregnancy foetus may suffer from erythroblastosis foetalis.
- Heart is two chambered in fishes, three in amphibian and reptilian and four in Aves & mammals.
- Human Heart is enclosed by pericardium.
- Atrioventricular septum is fibrous, whereas inter atrial and inter ventricular septum are muscular.
- Bicuspid (mitral) valve is between LA & LA.
- Tricuspid valve is between RA & RV.
- Semilunar valves are at base of aorta & pulmonary artery.
- SA node-Pacemaker.
- AV node-pacesetter.

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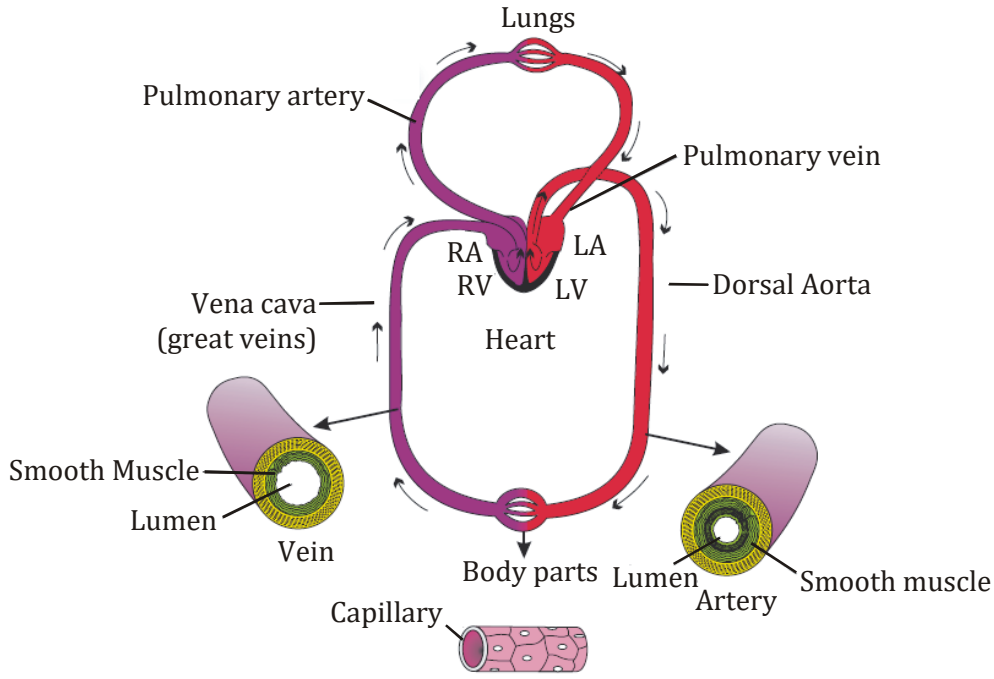
- Joint diastole is for 0.4 sec. and at this time, AV valves are open, semilunar valves are closed.
- Atrial systole is for 0.1 sec. and remaining 30% of ventricular blood fills at this time.
- Ventricular systole is for 0.3 sec., at this time, AV valves are closed and semilunar valves are open.
- Cardiac output (5L/min) = Stroke volume (70 ml) × Heart rate (72 / min.).
- First heart sound (Lub) is due to closure of AV valves and second (Dub) is due to closure of semilunar valves.
- P wave indicate depolarization of atria.
- QRS complex indicate depolarization of ventricles.
- T wave indicate repolarization of ventricles.



Schematic plan of blood circulation in human

- Cardiac centre is in medulla.
- Cardio accelerator send impulse by sympathetic fibres.
- Cardio inhibitory send impulse by para sympathetic fibres.
- Coronary artery disease-Narrowing of coronary artery.
- Heart failure → Heart is not pumping blood effectively.
- Cardiac arrest → Heart stops beating.
- Heart attack → Sudden death of heart muscle.
- Normal blood pressure → 120/80 mm Hg.

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